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(54) **FLEXIBLE NO-LASH DRIVE PLATE**

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(51) **Int. Cl.**[7] **B62D 1/00**; F16F 9/50

(52) **U.S. Cl.** **280/90**; 280/89.13; 188/267.2

(58) **Field of Search** 280/89, 89.13, 280/90; 188/267.1, 267.2; 180/417, 444

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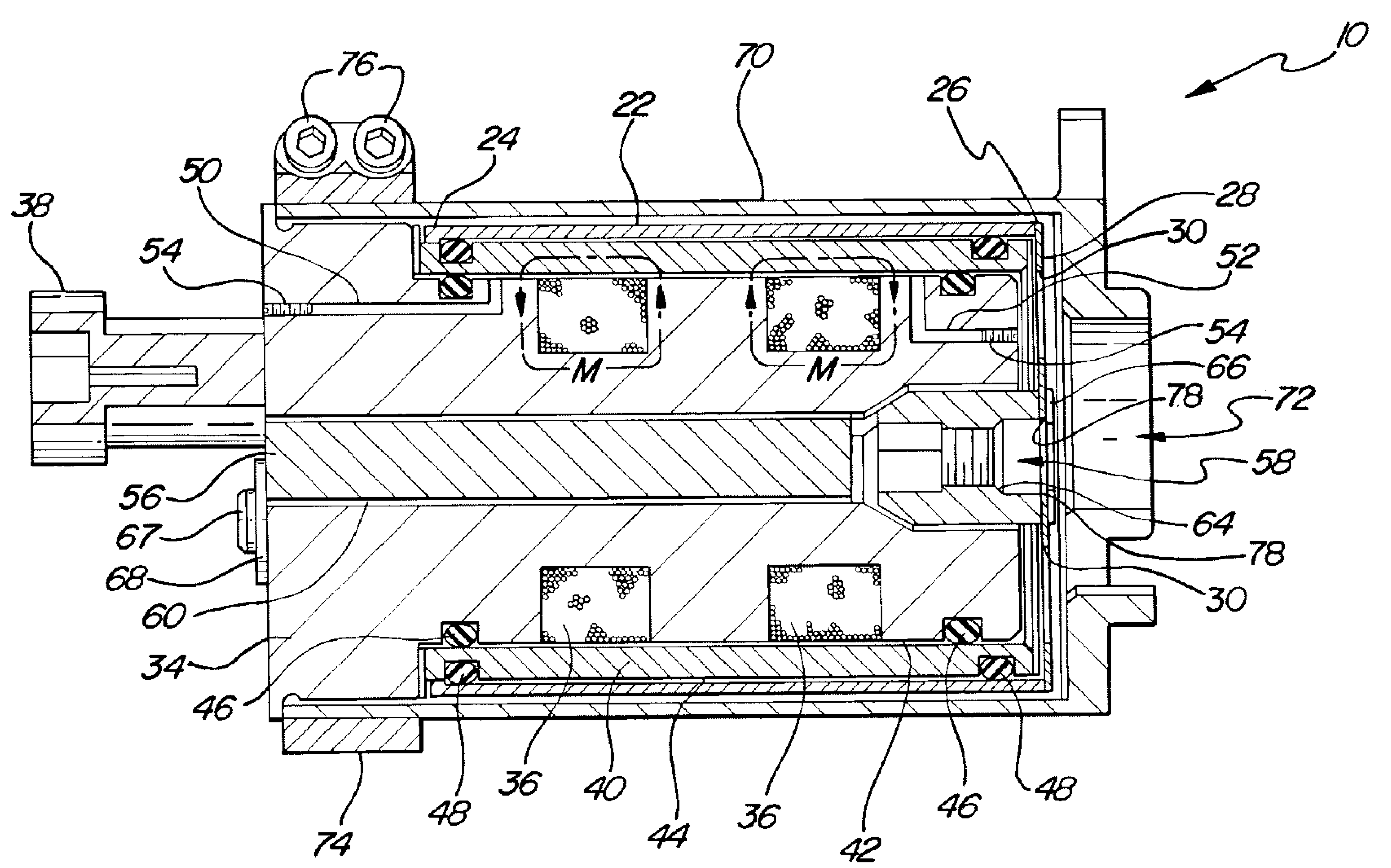
(57) **ABSTRACT**

The subject inventive steering damper assembly includes a rotor sleeve having open first and second ends and a drive plate disposed in the open second end. A core is co-axially disposed in the rotor sleeve closing the open first end of the rotor sleeve and defining a magnetic fluid chamber with the sleeve. A Magneto-Rheological fluid is disposed in the magnetic fluid chamber. The drive plate is flexible to provide manufacturing and operational tolerance, and is securely attached to the open second end of the rotor sleeve. Flexibility is derived from at least one aperture disposed in the drive plate. The aperture may be formed in a variety of shapes including elongated, round and oval shaped apertures.

6 Claims, 3 Drawing Sheets



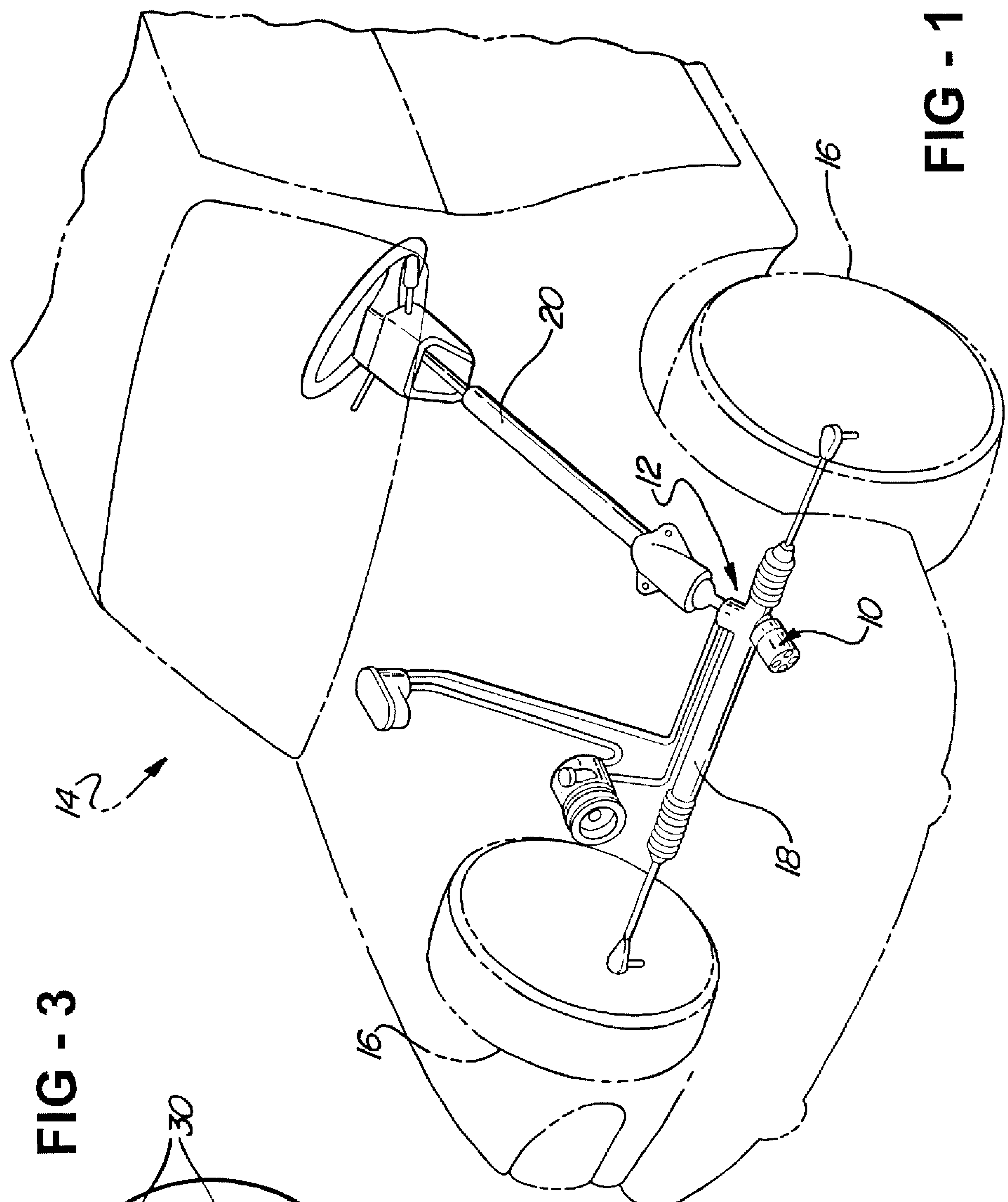


FIG - 1

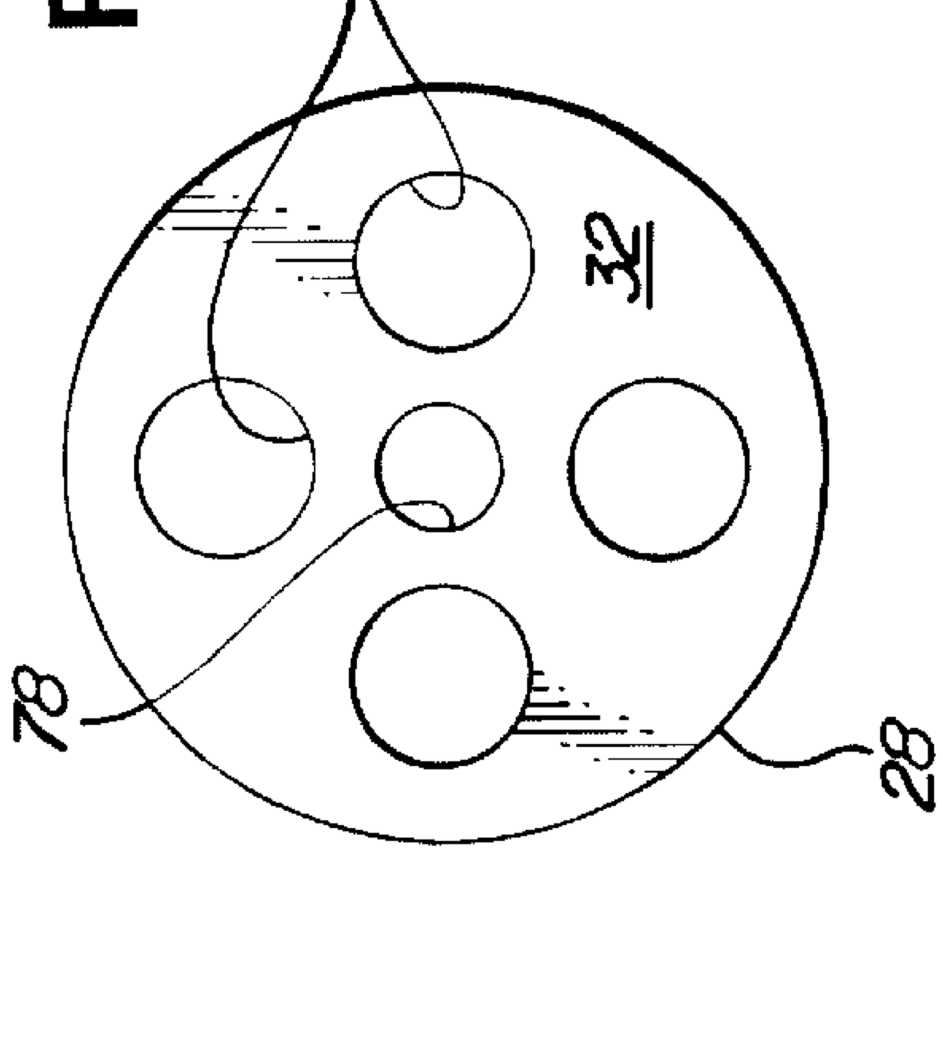


FIG - 3

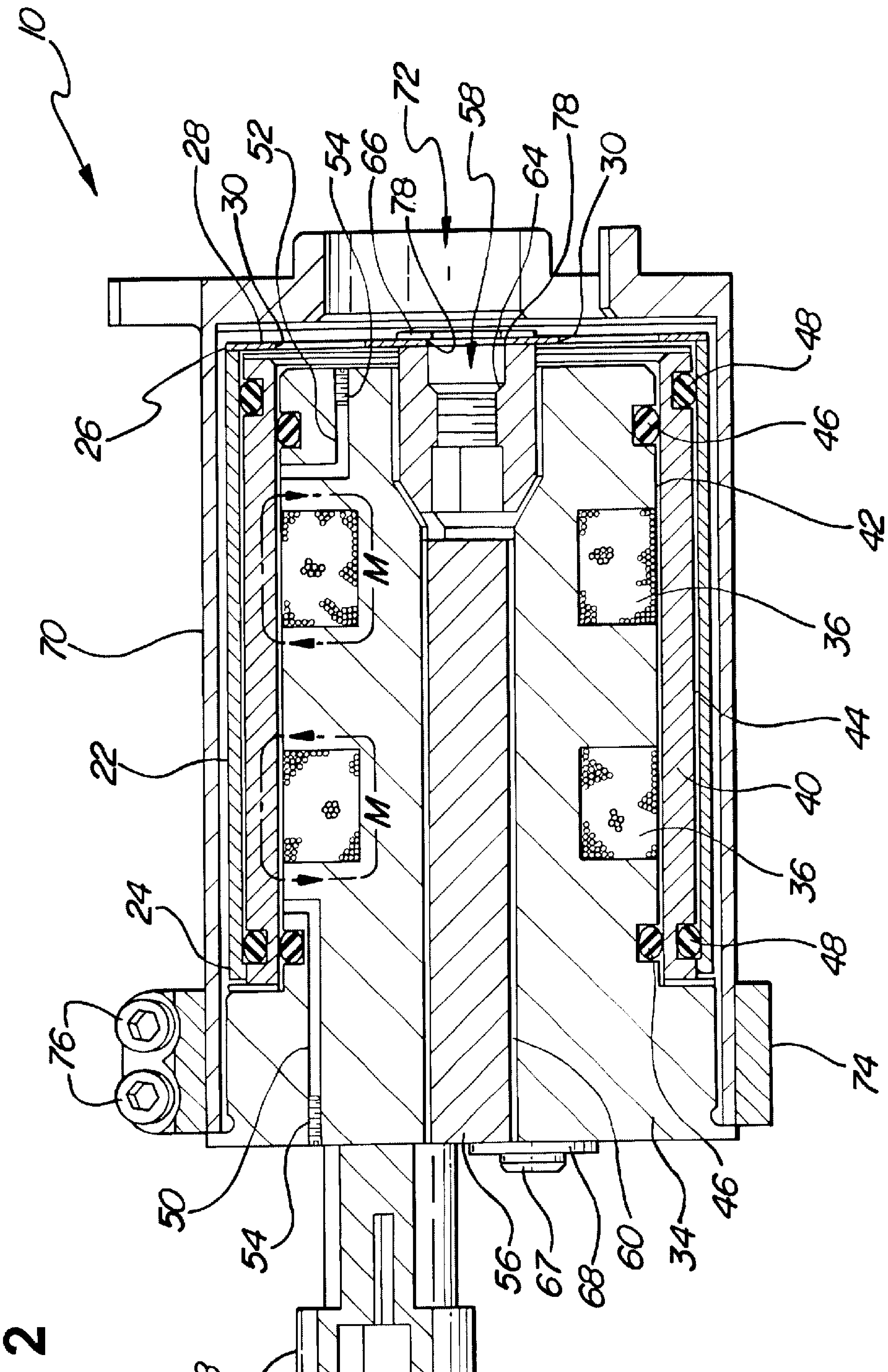

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FIG - 2

FIG - 4

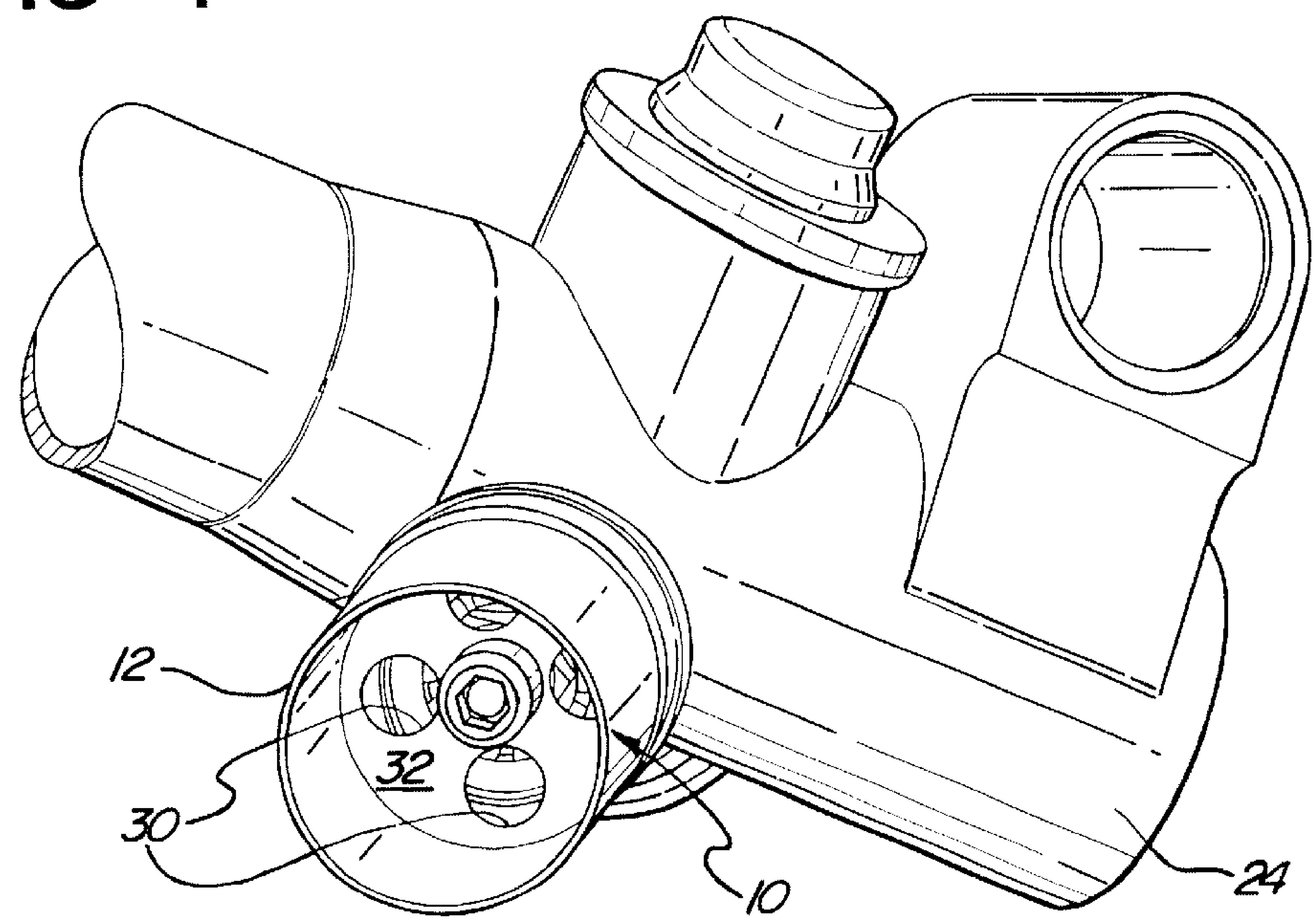
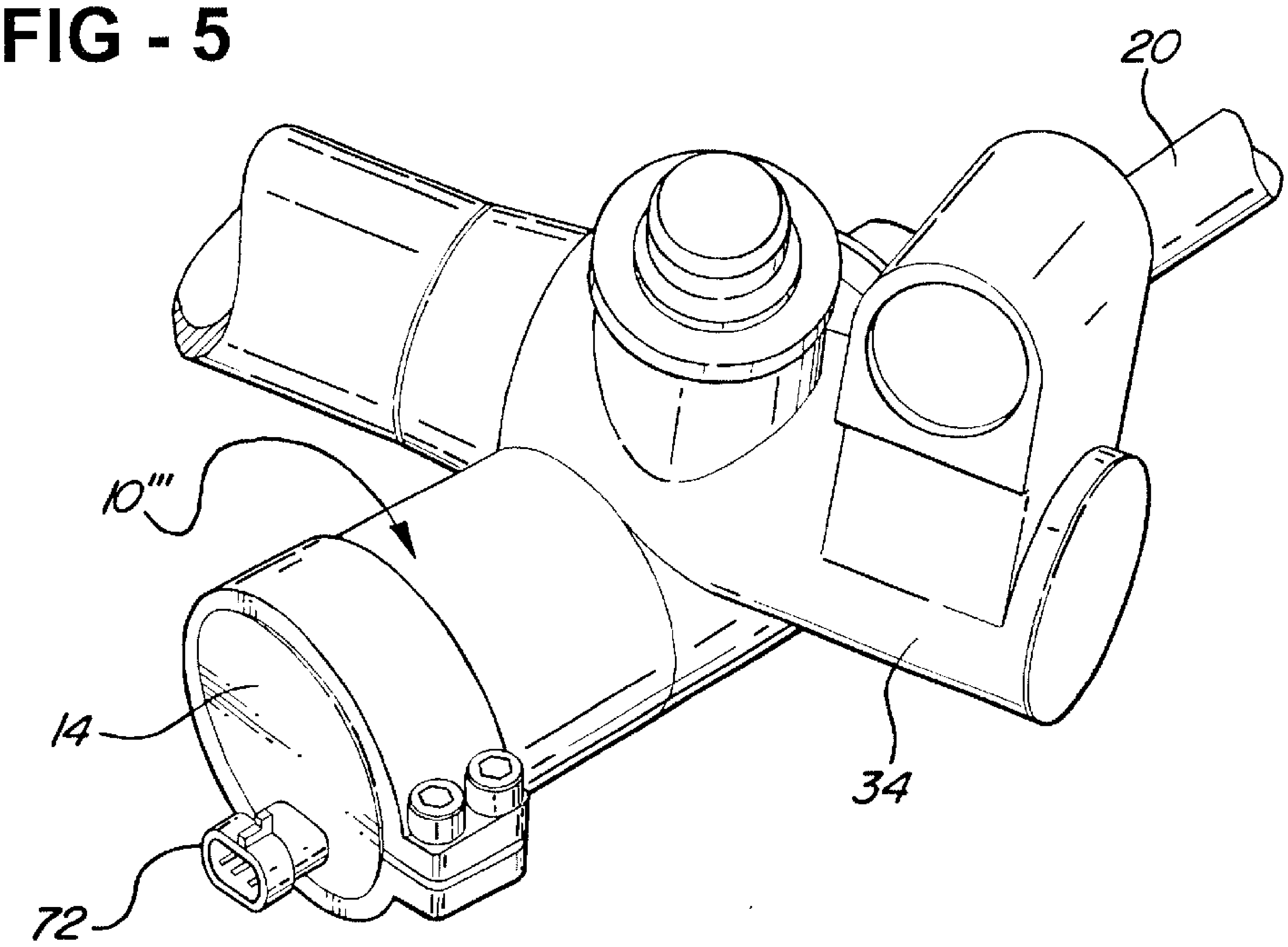


FIG - 5



FLEXIBLE NO-LASH DRIVE PLATE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The subject invention relates generally to vibration damping of suspension and steering systems in a motor vehicle. More specifically, the subject invention relates to vibration damping using a flexible drive plate in a rotary type damper.

2. Description of the Prior Art

Rotary dampers have been installed in both steering and suspension assemblies of motor vehicles to dampen the amount of vibration detected by the vehicle operator from such variables as vehicle speed, road bumps, wheel alignment, wheel chatter, and tread wear. Rotary dampers of this type reduce the amount of vibration transferred to the vehicle operator by resisting rotational velocity generated from a pinion associated with either the steering assembly or the suspension assembly. The rotational velocity is resisted by torque generated by the rotary damper thereby reducing the vibration transfer to the driver. The torque is derived from a clutch-like sheer resistance generated by a fluid, generally Newtonian, when a rotor disposed within a vibration damper assembly and operatively connected to the pinion receives rotational velocity from the pinion.

The rotational velocity generated by the pinion connected to the rotary damper varies with the amount of vibration absorbed from the operating variables. A variable level of torque is required to provide uniform damping at both high rotational velocities and at low rotational velocities.

A typical rotary damper assembly that utilizes Magneto-Rheological (MR) fluids includes a core disposed within a housing. The core is operatively connected to a rotational velocity-generating member, such as a pinion, that is connected to a steering or suspension assembly. A conductive sleeve is positioned between the housing and the core. A coil is positioned adjacent the sleeve and is capable of generating a magnetic field that is transmitted through the sleeve. An annular plate separates the core from the sleeve and defines a viscous chamber and a Magneto-Rheological fluid chamber. The viscous chamber is disposed between the sleeve and the housing and the MR chamber is disposed between the sleeve and the core. A viscous fluid is contained within the viscous chamber and MR fluid is contained within the MR chamber. The viscous fluid behaves as a Newtonian fluid throughout operation of the assembly. The MR fluid behaves as a Bingham plastic when it is subjected to the magnetic field and, otherwise, behaves as a Newtonian fluid.

The steering damper provides the ability to vary the amount of torque generated by the vibration damper assembly. When not subjected to the magnetic field, the torque is generated by the Newtonian fluid, which is preferable at low velocity. When subjected to the magnetic field, the MR fluid is transformed from a Newtonian fluid to a Bingham plastic, which generates a torque that is preferable at higher velocities.

Although this type of damper design has proven to be reliable, binding can occur when the rotor is pulled out of alignment with the core by the end of the pinion shaft as a result of misalignment due to production and dimensional tolerances. This misalignment, also known to those of skill in the art as runout, is a problem inherently due to dimensional tolerance conditions that allow axial misalignment. Also, any looseness or lash in the spline coupling between the pinion shaft and the rotor allows vibration to bypass the damper undamped. This looseness is due to necessary build clearances in the spline dimensions and normal wear.

SUMMARY OF THE INVENTION AND ADVANTAGES

The subject invention provides a steering damper assembly comprising a rotor sleeve having a first end adapted to be mounted to a pinion shaft. A drive plate is disposed on the open first end of the rotor sleeve. A core is co-axially disposed in the rotor sleeve and closes the open second end defining a magnetic fluid chamber between the core and the rotor sleeve. A Magneto-Rheological (MR) fluid is injected into the MR fluid chamber. The MR fluid includes a variable shear force when subjected to a magnetic field to provide a torque resistance to the rotational velocity derived from the pinion.

The drive plate is flexible and securely attached to the open first end of the rotor sleeve. The pinion is inserted through the drive plate and is secured by a nut. The drive plate receives flexibility from a plurality of drive plate holes disposed in the surface. The flexibility in the drive plate increases the manufacturing tolerance of the assembly. Therefore, if the pinion is not properly aligned with the core when being mated to the assembly, the drive plate will flex to provide a broader access to the core. Further, if the pinion is received by the core in a non-aligned orientation, the drive plate will remain in a flexed state to provide the necessary access to the core. Therefore, the damping properties of the assembly will not be reduced if the final alignment of the pinion with the core is not precise due to manufacturing variability. Clamping the drive plate to the pinion shaft with a nut provides an initial alignment and a lash free connection not provided by a splined connection.

A further advantage of the apertures bored through the flexible drive plate is the ability to inject damping fluid through the apertures into the steering damper assembly during the manufacturing process. Thus, the complexity and difficulty of manufacturing the steering damper is reduced with the addition of the apertures in the drive plate.

BRIEF DESCRIPTION OF THE DRAWINGS

Other advantages of the present invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

FIG. **1** is an environmental view of the inventive damper assembly attached to a steering assembly;

FIG. **2** is a sectional view of the inventive damper assembly;

FIG. **3** is a front view of the drive plate showing drive plate apertures;

FIG. **4** shows the drive plate **28** and rotor sleeve **22** attached to the pinion with the nut **64**. Other parts are not shown for clarity.

FIG. **5** is a perspective view of the inventive damper assembly interfacing to a steering assembly showing the damper housing.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. **1**, a steering damper assembly shown generally at **10**,is installed in a steering system generally shown at **12**,of a motor vehicle generally shown at **14**. The assembly **10** absorbs rotational energy derived from the wheels **16** of the motor vehicle **14** through the power steering assembly **18**. The rotational energy is derived from such driving variables as vehicle speed, road bumps, wheel misalignment, wheel chatter and tread wear. The assembly **10** reduces the amount of the vibrational forces transferred to a vehicle driver through a steering column **20** of the motor vehicle **14**.

The method by which the inventive assembly **10** reduces the vibrational forces transferred to the vehicle driver is best explained by referring to FIG. **2** wherein a cross-sectional view of the assembly **10** is shown. A rotor sleeve **22** defines a first opened end **24** and a second end **26** to which a drive plate **28** is affixed. The drive plate **28** is relatively thin and has planar sides extending radially inwardly from the open end **24** of the sleeve **22**. The drive plate **28** includes flexible characteristics that enable the drive plate **28** to absorb manufacturing variation from the assembly thereby improving the vibrational absorbing characteristics of the assembly **10**. The drive plate **28** may be attached to the rotor sleeve **22** through a variety of attaching methods including welding, fusing, soldering, flanging, bonding, and any number of equivalent methods of attachment.

As shown in FIGS. **3** and **4**, the drive plate **28** preferably derives flexibility from a plurality of drive plate apertures **30** disposed in a planar surface **32** of the drive plate **28**, In another embodiment of the present invention, flexibility in the drive plate **28** may also be derived through the utilization of a rigid substrate having a thickness enabling flexibility from the drive plates **28** original plane. Alternatively, a substrate having flexible and resilient qualities may also be used. Other novel aspects of the inventive drive plate **28** will be explained further below.

Returning to FIG. **2**, a core **34** is inserted through the first end **24** of the rotor sleeve **22**. The core **34** includes at least one coil **36** capable of receiving electric current thereby generating a magnetic field (M). Preferably, the assembly **10** will include at least two coils **36** to generate at least two magnetic fields (M). The coil **36** receives electric current through an electrical connector **38**, which receives electric current from the vehicle's electrical system (not shown) as directed by a controller (not shown). An inner sleeve **40** is disposed between the rotor sleeve **22** and the core **34**. The inner sleeve **40** defines a Magneto-Rheological fluid chamber **42** with the core **34** and a viscous fluid chamber **44** with the rotor sleeve **22**.

When subjected to the magnetic field (M) generated by the coil **36**, the sheer properties of the MR fluid are altered. When not subjected to a magnetic field, the MR fluid behaves much like a Newtonian fluid providing a sheer resistance resembling a Newtonian fluid. However, when subjected to a magnetic field, the sheer resistance of the MR fluid is increased proportionally to the strength of the magnetic field (MR). Under the magnetic field, the MR fluid behaves like a Bingham plastic providing a sheer resistance resembling a Bingham plastic. Therefore, the assembly **10** can provide a variable amount of vibrational resistance by adjusting the amount of sheer forces in the MR fluid relative to the strength of magnetic field (M) the fluid is subjected to.

As stated above, the MR fluid retains Newtonian sheer characteristics when not subjected to the magnetic field (M). The viscous fluid retains Newtonian properties throughout operation of the assembly **10**. When subjected to the magnetic field (M) generated by the coil **36**, the viscosity of the MR fluid increases and stabilizes establishing sheer characteristics of a Bingham plastic. Therefore, a variable amount of torque can be generated by the core **34** through the combination of the viscous fluid and the MR fluid. When the coils **36** are not energized and the MR fluid is not subjected to a magnetic field, the MR fluid provides less resistance to movement than the viscous fluid In this state, relative rotation of the damper parts occurs across the MR fluid chamber **42**, with damping provided by the MR fluid viscosity. When a low level of coil excitation provides a low-level magnetic field M, the MR fluid becomes more viscous and provides more damping. As the coil excitation and magnetic field is increased, the damping provided by the MR fluid is increased until the damping provided by the MR fluid exceeds the damping provided by the viscous fluid. In this state, the relative rotation and damping occurs in the viscous fluid, providing an upper limit to damping torque provided.

An MR seal **46** is disposed at each end of the MR fluid chamber **42** to prevent MR fluid from leaking out of the chamber **42**. Likewise, a viscous seal **48** is disposed at each end of the viscous chamber **44** to prevent viscous fluid from leaking from the viscous chamber **44**.

A first MR fluid bore **50** and a second MR fluid bore **52** are disposed in opposing ends of the core **34**. MR fluid is injected into the MR fluid chamber **42** through one of the first and second MR fluid bores **50, 52**, subsequent to affixing the inner sleeve **40** over the core **34**. Air and excess MR fluid is allowed to flow out of the MR fluid bore **50, 52** not being used to inject the MR fluid into the MR fluid chamber **42**. Subsequent to filling the MR fluid chamber **42** with MR fluid, the first and second MR fluid bore **50, 52** are sealed with plug screws **54**. Therefore, it is preferable that the ends of the MR fluid bores **50, 52** are threaded to threadably receive the plug screws **54**.

A core plug **56** is received by a center bore **58** disposed along a pivotal axis of the core **34**. A plug sleeve **60** receives the core plug **56** prior to inserting the core lug **56** into the center bore **58**. The core plug **56** includes magnetic properties to the magnetic characteristics of the magnetic field (M). The center bore **58** increases in diameter at the second end **26** of the rotor sleeve **22** to receive a pinion (not shown) from the power steering assembly **18**. A female threaded nut **64** is disposed in the center bore **58** in the larger diameter area of the center bore **58** to secure the pinion to the drive plate **28**. A spacer washer **66** is positioned between the female nut **64** and the pinion to clamp the plate **28** between the pinion and the core plug **56** around the center bore **58**.

Subsequent to assembling each of the components to the core **34** including the rotor sleeve **22**, the inner sleeve **40**, and the core plug **56**, an assembly case **70** is secured thereover. The case **70** includes a pinion bore **72**, which provides access to the female nut **64** and the center bore **58** for the pinion **62**. The case **70** is secured to the core **34** with a clamp **74**. At least one clamp screw **76** is used to tighten the clamp **74** around the case **70**.

As demonstrated in the description detailed above, the pinion is inserted through a central aperture **78** and the drive plate **28** and is secured by a nut **64** as best seen in FIGS. **2** and **4**. Due to the flexible nature of the drive plate **28**, slight angular misalignments of the pinion with the drive plate **28** and rotor sleeve **22** will not adversely affect the performance of the assembly **10**. Clearance is provided between the central aperture **78** and the pinion. This allows the rotor sleeve **22** and the inner sleeve **40** to be held in alignment with the core **34** by the centering actions of the seals **46, 48** while the nut **64** is tightened to secure the flex plate **28** to the pinion. The drive plate aperture **30** provides additional manufacturing benefits to the assembly **10**. It should be understood that the viscous fluid may optionally be injected through the drive plate aperture **30** into the viscous fluid chamber **44** during the manufacturing process.

FIG. **5** shows a close-up view of the inventive steering damper assembly **10** affixed to a pinion of the steering assembly **18**. Vibrations generated in the steering assembly **18** are transformed to the steering column **20** in the form of rotational velocity. The rotational velocity is absorbed by the steering damper assembly **10** due to the torque generated by the shear forces in the viscous and MR fluids.

Obviously, many modifications and variations of the present invention are possible in light of the above teachings. The invention may be practiced otherwise than as specifically described within the scope of the appended claims.

What is claimed is:

1. A steering damper assembly comprising:

a rotor sleeve having open first and second ends;

a core co-axially disposed in said rotor sleeve and closing said open second end defining a magnetic fluid chamber therebetween for receiving a Magneto-Rheological (MR) fluid therein said core including a centrally disposed core plug; and

a relatively thin drive plate having planar sides extending radially between said open first end of said rotor sleeve and said core plug for being driven with said core plug and being flexible for flexing circumferential between said core plug and said rotor sleeve.

2. A steering damper assembly as set forth in claim **1** further including an inner sleeve disposed in and concentrically aligned with said rotor sleeve for defining a viscous fluid chamber between said inner sleeve and said rotor sleeve, said inner sleeve coaxially disposed about said core defining said magnetic fluid chamber.

3. A steering damper as set forth in claim **2** further including a case having an end adapted to receive a pinion shaft, said case coaxially disposed about said rotor sleeve defining a rotation chamber between said tubular sleeve and said rotor sleeve, said rotor sleeve rotating therein in response to a force.

4. A steering damper assembly as set forth in claim **3** further including a clamp assembly disposed on said case for clamping said case to said core.

5. A steering damper assembly as set froth in claim **1**, said drive plate being thin enough to flex out of its plane in response to a load.

6. A steering damper assembly comprising:

a rotor sleeve having open first and second ends;

a drive plate disposed on said open first end of said rotor sleeve and being matable to a pinion;

a core co-axially disposed in said rotor sleeve and closing said open second end defining a magnetic fluid chamber therebetween for receiving a Magneto-Rheological (MR) fluid therein; and

wherein said drive plate is flexible and securely attached to said open first end of said rotor sleeve; and

wherein said drive plate defines at least one aperture for providing flexibility to said drive plate.

* * * * *